Introduction

- Overview of parachute sizes and mass for given entry mass
- Design drivers
- Design cases
- Materials
- Planform
- Testing

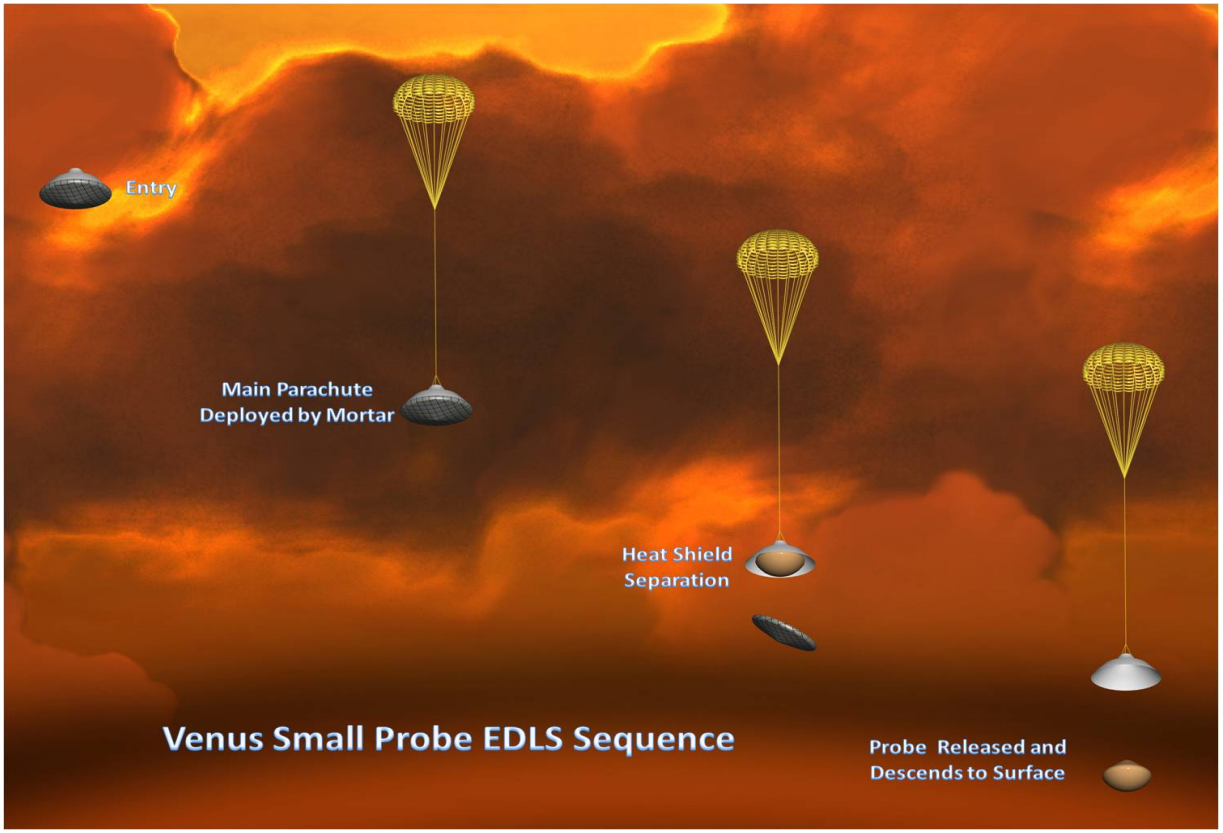
Design Drivers

- Highly Corrosive Atmosphere
  - Sulfuric Acid
  - Drives material selection
- Similar Atmospheric Density at Deployment Altitude to Earth
  - At 50 km, 1 Bar, 75ºC
  - Simplifies testing
- Rate of Descent
  - Typically at a proscribed altitude, not at landing due to thick atmosphere
- Deployment
  - Mortar deployed parachute to push parachute through base region of reverse flow behind vehicle

Small Probe Sequence

Airborne Systems™

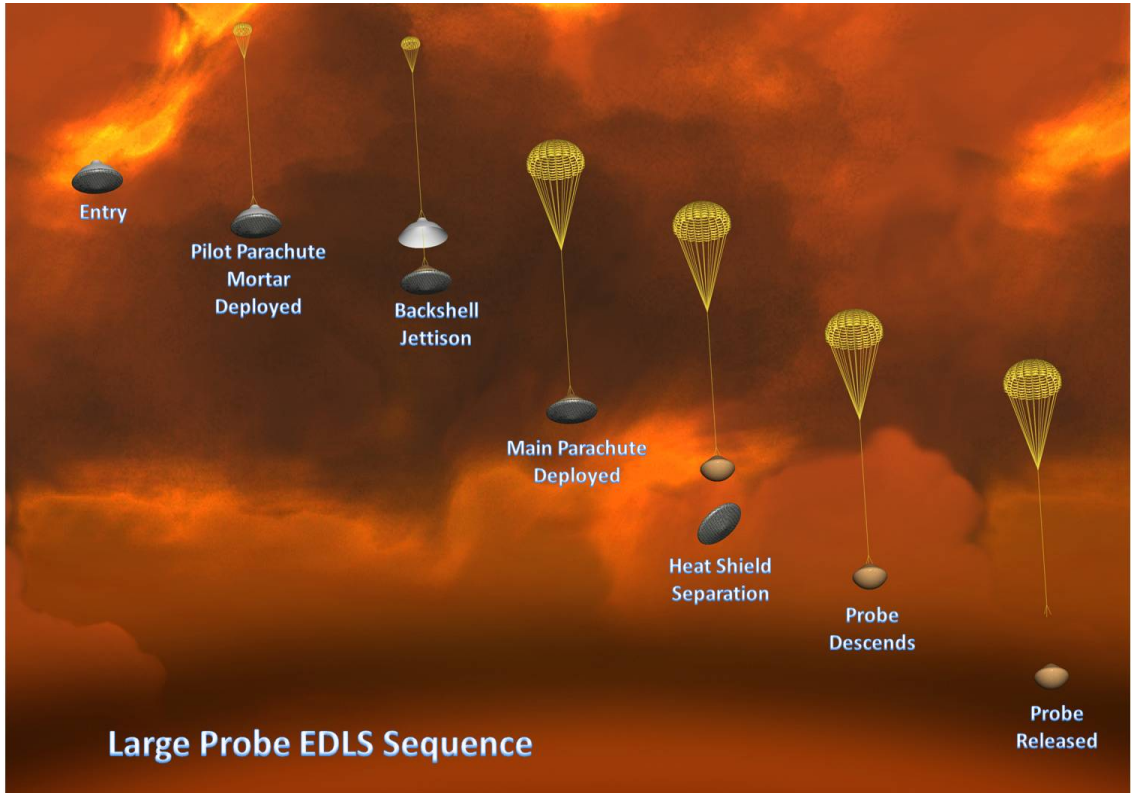
- 100 kg entry mass
- Mortar deployment of main parachute
- Heat shield separation after stabilization
- Release probe at required point
- 1.8 m parachute
- 2.5 kg total mass, mortar and parachute



Large Probe Sequence

Airborne Systems™

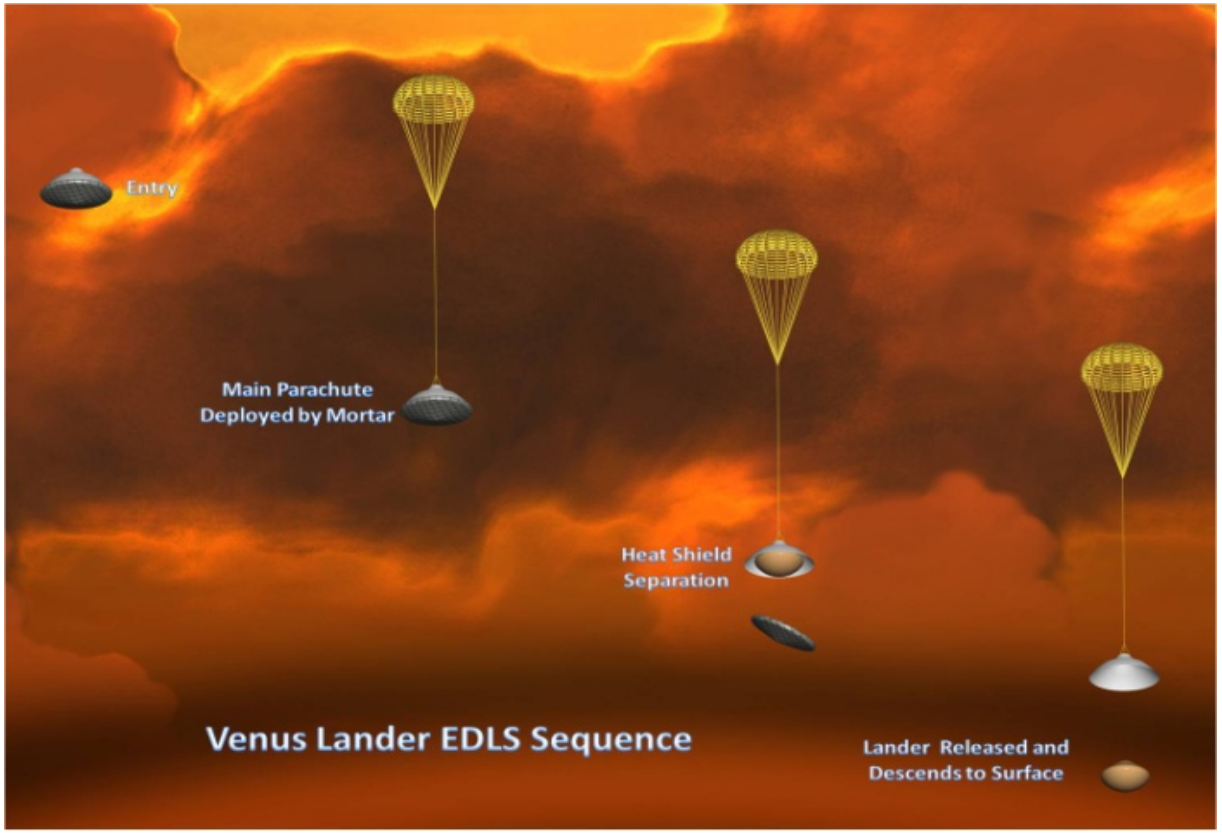
- 500 kg entry mass
- Mortar deployment of pilot parachute
- Backshell released immediately following pilot mortar fire
- Pilot separates backshell, extracts main parachute



- Heat shield separation after stabilization
- Release probe at required point
- 5.0 m parachute, 7 kg total system mass

Lander Sequence

- 1,000 kg entry mass
- Mortar deployment of main parachute
- Heat shield separation after stabilization
- Release lander at required point
- 5.0 m parachute



- 11 kg total mass, mortar and parachute
  - Higher mass due primarily to larger mortar

Other Options

- Higher deployment Q
  - Typical Venus mission deploy M=0.80
  - Conical ribbons deploy reliably up to M=2.0
- Larger parachute
  - Conical ribbons over 12 m have been flown
  - Allows ~2,000 kg entry mass

Materials

- Sulfuric acid clouds at parachute deployment altitudes
  - 50 to 62 km
  - 80% concentration at 80ºC
- Pioneer Venus used Dacron®
- Current choice fabric is Vectran®
  - High tenacity liquid crystal polymer
  - Very resistant to sulfuric acid
  - Has space heritage
    - Airbags for Pathfinder, Mars Exploration Rovers
  - Meets total mass loss and collected volatile condensable mass requirements

Planform

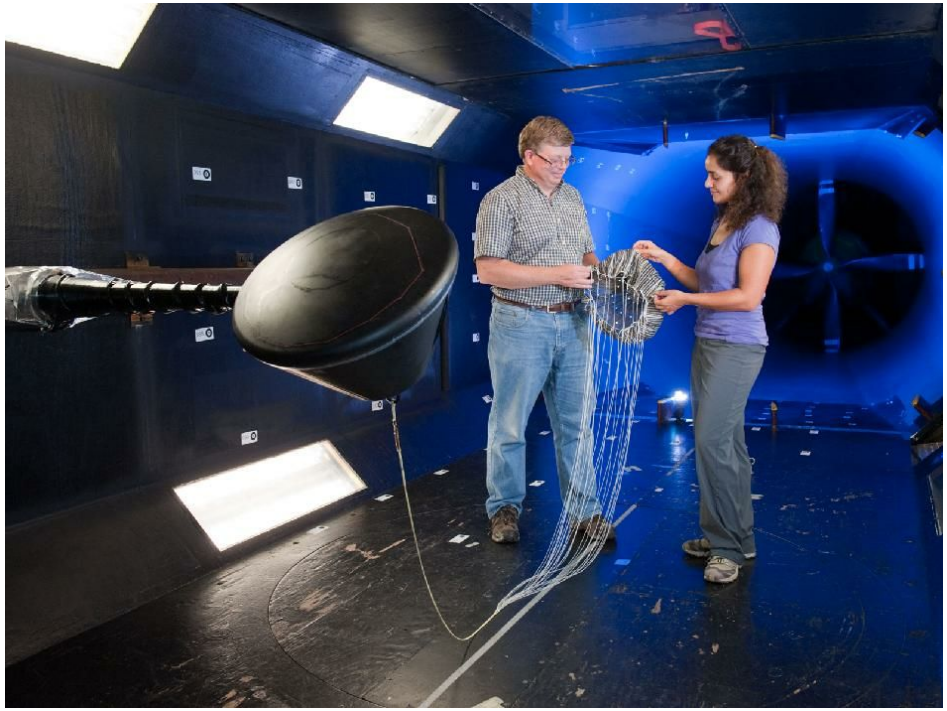
- Pioneer Venus used ribless guide surface drogue and conical ribbon main
  - Intended architecture was RGS for both
  - 1.37 m RGS pilot performed well in testing
  - 6.74 m RGS main demonstrated inflation and equilibrium problems
  - Substituted 4.5 m conical ribbon
- Use heritage RGS pilot for small probe, or large probe pilot
- Use heritage conical ribbon main for lander or large probe main
- Investigate other options such as variable porosity conical ribbon if need to qualify a new parachute

Full Scale Testing

- Qualify components individually, then complete system end-to-end flight test
- Recent and current Mars missions all use Viking data from tests in early 1970's
- Leverage data from Pioneer Venus and extensive parachute testing conducted in 1960's and 1970's
- Two options for end to end testing
  - High altitude balloon drop
    - Sacrifices angle of attack and flight path angle for less expensive testing
  - Intermediate altitude balloon drop with rocket boost
    - Achieves specific angle of attach and FPA

Scaled Testing

- Until recently, scaled testing of ribbon parachutes not practical
- NASA has successfully tested a 10% scale model of Orion capsule drogue parachute (VPCR)
- Results compare favourably with drop test data from Orion test campaign
- Note that scaled testing can augment full size testing, not replace it.



10% Scale Conical Ribbon in Texas A&M Low Speed Tunnel
(Photo courtesy of NASA)


Questions?